

# An Analysis of Concentration Region on Powerpoint Slides using Eye Tracking

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**Abstract**—Powerpoint slides have become one of the essential teaching tools in academic for both offline and online modes. It may play a useful role to facilitate discussion and information exchange. However, in our teaching experience, we find many students utilizing Powerpoint slides beyond their traditional functions. Many students fully rely on the slides as the main learning materials and, in some cases, substituting textbooks. This study intends to understand how students interact with the learning materials presented on Powerpoint slides. The interaction is measured using an eye tracker device called the Eye Tribe Tracker. Thirty sophomore and junior students are asked to participate. They are instructed to learn a topic in the subject of Introduction to Algorithm and Programming, a basic course in the computer science field. During the process, their fixation points are monitored and are related to the contents on the slides. The results are rather surprising. Many students read the slides in unexpected manners that may compromise their understanding and may lead to inaccurate interpretations.

## I. INTRODUCTION

E-learning is one of the widely deployed learning modes by schools and universities across the globe [1]–[3]. It has some benefits over the traditional classroom-based learning. It has rather flexible learning time and place. The students can learn at their pace.

In the recent learning-teaching activities, PowerPoint slide has become an important learning medium besides books, printed or electronic, lecture videos, and group discussions for the traditional class-based learning as well as online one [4]. In the other side, many researchers have identified the drawbacks of using PowerPoint slides in the learning-teaching activities as well as in general presentations [5]. Mohammad and Leng [4] and Young [6] found that the students quickly get bored in the class where the slides were continuously used. Mohammad and Leng [4] also discovered that the use of slides prevented deep learning and discussion, and reduced the learning motivation. It was hard for students to maintain their concentration on wordy slides [3]. The teachers who used slides tend to use the slides as the main teaching tool, reading directly from the slides and paying less attention for nurturing a constructive discussion environment [7]. Finally, Nouri and Shahid [8] found that the use of slides tended to promote a passive learning.

This research intends to acquire understanding in a deeper level regarding how learners interact with slides and to understand how they lose their concentrations. For the purpose,

the learner fixation region on slides is continuously monitored using an eye tracking device. The region is then related to the learning materials on the slides. The study assumes that the fixation area is somehow related to their concentrations.

The use of eye tracking method to understand how learners interact with learning media has been previously deployed [9]–[15]. For example, Tsai et al. [9] observed the eye movements when the learners read books. Clark et al. [10] studied a similar case where the learners navigated through Wikipedia web pages.

In this study, we seek to understand the following two research questions. The first is how learners navigate across lecture slides. The second is to understand how the level of attention changes with the increasing number of slides.

## II. RESEARCH METHOD

Our objective is to understand how students learn by using Powerpoint slides. We assume that to learn materials from slides, students should firstly bring their attention strictly to the materials on the slides. We understand that the learning process is complex. Quantifying the process by the gazing position only is over simplification. However, we certainly believe that gazing the learning materials is necessary to acquire the knowledge.

We select 30 sophomore and junior students of the Computer Science Department of Bina Nusantara University. The University is a rather large private institution in Jakarta. It is well-known in Indonesia for its computer science program. They are provided laptop computers with PowerPoint slides. The slides present a topic about the data structure of the modern computer. The topic is from the course Introduction to Algorithm and Programming.

### A. The Eye Tracker Device

The used eye tracker device is the Eye Tribe as presented in Fig. 1. It has the specifications as presented in Table I.

The experiment setup is shown in Fig. 2. The device is placed at a position in between the computer monitor and the participant. The participant should be positioned in the center-front of the monitor at a distance within the range of 45–75 cm as depicted in Fig. 2(a). The tracker should be oriented toward the participant's face as depicted in Fig. 2(b).



Fig. 1. The used eye tracker device called the Eye Tribe (source: www.ippinka.com).

TABLE I  
THE SPECIFICATION OF THE USED EYE TRACKER DEVICE

Sampling rate	30 Hz and 60 Hz mode
Accuracy	0.5° (average)
Spatial resolution	0.1° (RMS)
Latency	< 20 ms at 60 Hz
Calibration	5, 9, 12 points
Operating range	45–75 cm
Tracking area	40 × 30 × cm at 65 cm distance
Screen sizes	Up to 24 inches
API/SDK	C++, C# and Java included
Data output	Binocular gaze data
Dimensions	(W/H/D) 20 × 1.9 × 1.9 cm
Weight	70 g
Connection	USB 3.0 Superspeed



(a)



(b)

Fig. 2. The eye tracking experimental setup. (a) The participant should be centered positioned in front of the monitor within the distance of 45–75 cm. (b) The tracker face should be oriented toward the participant face.

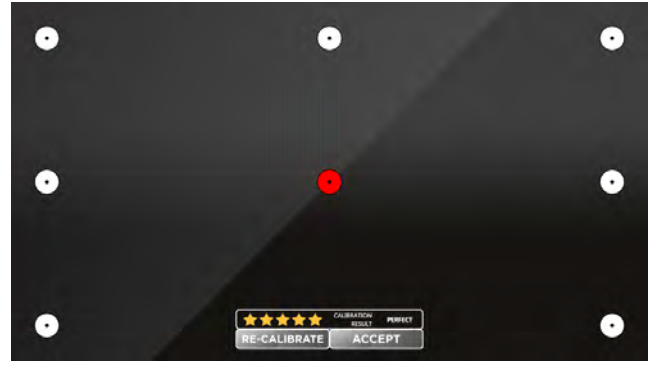


Fig. 3. The nine points that used to calibrate the orientation of the eye tracker. The point in the red color is active; thus, the participant should focus his/her gaze to the point.

TABLE II  
A BRIEF DESCRIPTION OF THE CONTENT OF EACH SLIDE USED IN THE STUDY.

Slide Number	The Brief Description of the Slide Content
0	Front cover
1	Learning outcomes
2,3	Variable declarations, e.g., <code>int x</code>
4–8	Data types, e.g., <code>int</code> , <code>char</code>
9	Casting, e.g., <code>(int) 3.14</code>
10–12	Constants, e.g., <code>#define PI 3.14</code>
13–14	Program examples
15	Operators, e.g., <code>sizeof</code>
16–19	Suffix, e.g., <code>3.15L</code> , <code>3.14f</code>
20–29	Outputs, e.g., <code>printf()</code>
30–46	Inputs, e.g., <code>scanf()</code>
47–51	Exercises
52	Summary

Prior the data collection, the eye tracking device should be calibrated for an accurate measurement. To facilitate the calibration, the participant is asked to gaze to the nine points depicted in Fig. 3, one point at a time. During the process, the participant should gaze the point that just turned red. Shortly after the process is finished, a message, describing the measurement accuracy, is presented. The message is 'Perfect' for the calibration accuracy of  $< 0.5^\circ$ , 'Good' for  $< 0.7^\circ$ , 'Moderate' for  $< 1.0^\circ$ , 'Poor' for  $< 1.5^\circ$ , and 'Re Calibrate' for the condition that is no good for eye tracking.

### B. The Presentation Materials

The number of slides provided to the respondents is 52 slides. All slides are about Introduction to Algorithm and Programming in C computer language. The session learning objectives are: for the participants to be able to define elements and structure of computer programs in C language. The contents of each slide are briefly described in Table II.

## III. RESULTS AND DISCUSSION

We assume that the gaze point is somehow related to the concentration and in some degree, it can be used to represent the concentration level. To concentrate on a word on the slide,



Fig. 4. The consensus of the color used to describe the gaze intensity. The color closer to the right denotes the higher gaze intensity.

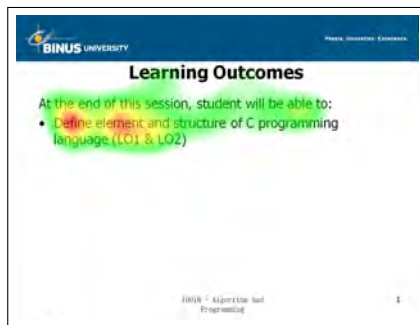


Fig. 5. The fixation map of the Slide 1. This is the first slide after the cover slide. The slide contents are rather limited. The respondents were able to fix their gazes across the entire contents.

the learner should first bring their focus to the word. Thus, fixing the gaze is a prerequisite condition to the concentration.

The fixation points are presented in a color map. These points are averages of the fixation points of all respondents. The relation between the color and the fixation intensity is depicted in Fig. 4. The red color means the highest intensity level; the green color means the medium; and, the white color means the lowest.

In the following, we discuss the learner regions of concentration. Some results are rather interesting phenomena. Although we display 52 slides, the fixation dynamics on eight slides are the most interesting. They are discussed in detail in the following.

The first result is depicted in Fig. 5. This slide is actually the second slide after the cover slide. It has rather limited contents. As the results, the respondents can fix their gazes on the entire slide contents.

The second interesting result is shown in Fig. 6. It has more contents than the previous slide. The gazed region seems to be in the upper-left part of the slide. In our perception, the encrypted parts, “<data type> <variable name> = <initial value>;”, are important, but the respondents seem to pay less attention on the region. But, they do focus on the examples:

```
int a, b, c, total;
float salary, bonus;
int num_students = 20;
```

These facts suggest that examples are more interesting to the learners. Perhaps, examples are easier to understand. We conceive the idea that exchanging the part of ‘Declaration format’ and the part of ‘Examples’. This approach may be better. By this approach, firstly, they learn the examples, and then, they generalize their understanding.

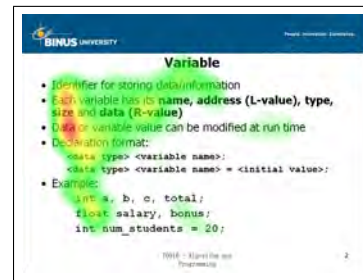


Fig. 6. The fixation map of the Slide 2. The respondents concentrate their gazes on the upper-left portion of the slide.

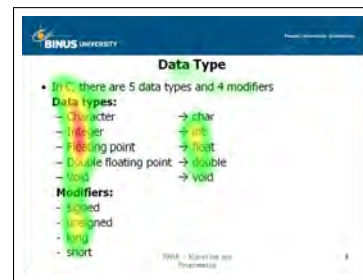


Fig. 7. The fixation map of the Slide 4.

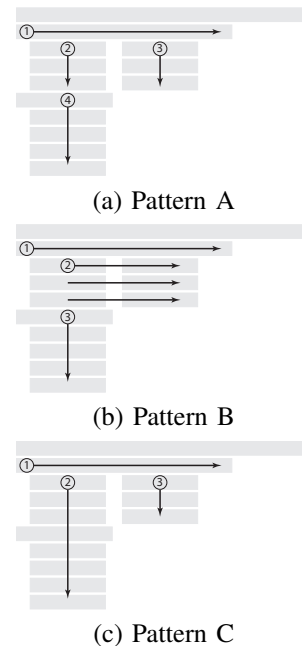


Fig. 8. The three respondent reading patterns for the Slide 4, depicted in Fig. 7. The proportions of the respondents were 17% with the Pattern A, 76% with the Pattern B, and 7% with the Pattern C. The correct reading pattern is the Pattern B.

The third interesting result is shown in Fig. 7. The slide contains some keywords of C programming language in an itemized arrangement. The content arrangement is rather complex. In this case, we observe three fixation patterns: A, B, and C as depicted in Fig. 8. The results are 17% respondents fixing following Pattern A, 76% Pattern B, and 7% Pattern C. Pattern B is the correct one.

DATA TYPE	SYNTAX	MEMORY	RANGE
character	assigned char	1 byte	0 to 255
	char	1 byte	-128 to 127
integer	unsigned int	2 byte	0 to 65535
	int	2 byte	-32768 to 32767
	short int	1 byte	-128 to 127
	unsigned long	4 byte	0 to 4294967295
	long	4 byte	-2147483648 to 2147483647
float	float	4 byte	3.4E-38 to 3.4E+38
	double	8 byte	1.7E-308 to 1.7E+308
	long double	16 byte	3.4E-4932 to 1.1E+4932

Fig. 9. The fixation map of the Slide 6. This slide contains rich information in table form with entries of keywords and numbers. The respondents have a few different ways to scan the table entries.

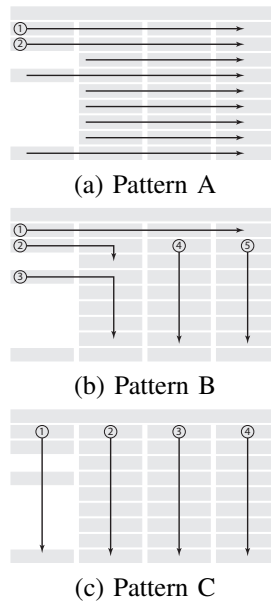


Fig. 10. The observed three reading patterns of the respondents for the Slide 6, depicted in Fig. 9. Nearly 50% respondents scanned the entries line by line, from the left to the right, from the top to the bottom (Pattern A). Ten percents scanned line by line from the top only for the two most left columns; after finishing the two columns, they scanned vertically entries in the third column, and then, the last column (Pattern B). Ten percents scanned column by column, from the most left column to the most right column (Pattern C). The reading Pattern A is the most appropriate one.

The fourth interesting result is observed on the slide depicted in Fig. 9. This slide contains rich information presented in a table with entries of C programming keywords and numbers. The respondents have a few different ways to scan the table entries as presented in Fig. 10. The three most common fixation patterns are of the following. Nearly fifty percents respondents scan the entries line by line, from the left to the right, from the top to the bottom (Pattern A). Ten percents scan the contents line by line from the top only for the two most left columns; after finishing the two columns, they vertically scan entries in the third column, and then, the last column (Pattern B). Ten percents scan column by column, from the most left column to the most right column (Pattern C). Clearly, the reading Pattern A is the most appropriate.

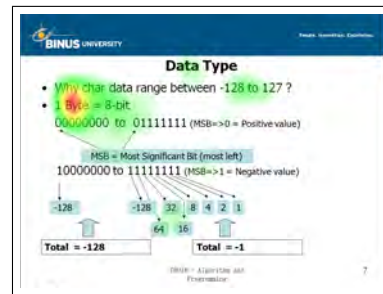


Fig. 11. The fixation map of the Slide 7. The slide contents are distributed vertically and those in the bottom half seems rather hard and requires more time to understand. The respondents mainly fix their attention on the upper half portion.

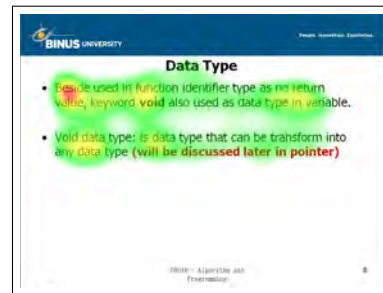


Fig. 12. The fixation map of the Slide 8. The slide contents are limited to two items, each is a full sentence. The respondent fixation points are distributed uniformly across the slide contents.

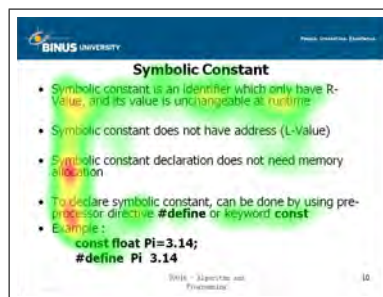


Fig. 13. The fixation map of the Slide 10. The slide contents are arranged in the way similar to that in Slide 8, see Fig. 12. However, the slide contents are distributed across five bullet points. The respondent fixation points are also distributed uniformly, similar to the case of the Slide 8.

The fifth interesting result is depicted in Fig. 11. Its contents are distributed vertically and those in the bottom half seems rather hard and requires more time to understand. The respondents mainly fixed their attention on the upper half part.

The sixth interesting result is depicted in Fig. 12. The slide contents are limited at two items, each item has a full sentence. The respondent fixation points are distributed uniformly across the slide contents.

The seventh interesting result is depicted in Fig. 13. The slide contents are arranged in the way similar to those in Fig. 12. However, this slide contents are distributed across five bullet points. The respondent fixation points are also distributed uniformly, similar to the case in Fig. 12.



The eighth interesting result is depicted in Fig. 14. The slide contains fragment of codes distributed in three block areas. The fixation pattern of all respondents is similar. Firstly, they fixed on the left-upper block, then, they moved to the right-upper block, and finally, to the bottom block. The contents on each block was scanned line by line.

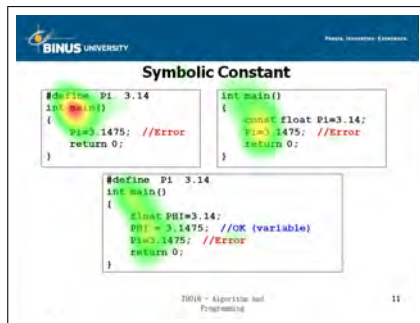


Fig. 14. The fixation map of the Slide 11. The slide contains fragment of codes distributed in three block areas. The fixation pattern of all respondents are similar. Firstly, they fixed on the left-upper block, then, they moved to the right-upper block, and finally, to the bottom block. The contents on each block was scanned line by line.

#### IV. CONCLUSIONS

This study investigates the way learners interact visually with the contents of the lecture PowerPoint slides. The visual attention is monitored using an eye tracking device. The results suggest that for the slides with complex content arrangements, the learners have significant chances to engage with materials in unexpected manner such that it may lead to wrong understanding.

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